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NON-PARAMETRIC METHOD OF STATISTICAL ANALYSIS OF RELIABILITY INDICATORS OF AVIATION PRODUCTS

Hifz Ur Rehman
National Aviation University, Kyiv
Research supervisor – Viktoriia Kravchenko, senior lecturer

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Introduction. Reliability of aviation equipment is the most important element of its quality. Therefore, the task of assessing the reliability indicators of component products is relevant for aviation engineering.[1]

Let them examine N products of the same type with an unknown but equal probability of failure $q(t)$. During the operation time T, the number of failed elements is a random variable with a binomial distribution law.

1. Let's find a point estimate of the probability of failure-free operation $P = 1 - q$ using the maximum likelihood method. [2] The likelihood function has the form:

$$L(q) = \binom{N}{n} q^n (1-q)^{N-n}. \quad (1)$$

The point unbiased effective estimate q^* for the probability of failure during operation T is

$$q^* = \frac{n}{N}, \quad (2)$$

The point unbiased effective estimate for the probability of failure-free operation:

$$P^* = 1 - \frac{n}{N}. \quad (3)$$

Based on the sample characteristics of the quantity q^*, determine the lower q_1 and upper q_2 confidence limits of the general characteristic q and the confidence interval $(q_1; q_2)$, which covers q with a two-sided confidence probability $\propto^*$.

$$\propto^* = P(q_1 \le q \le q_2), \quad (4)$$

One-sided confidence probabilities satisfy the following conditions:

$$\propto_1 = P(q \ge q_1), \propto_2 = P(q \le q_2).$$

Hence $$\propto^* = \propto_1 + \propto_2 - 1.$$

$$R_0 = N(1 - \sqrt[N]{1-\propto}),$$

$$R_1 = \frac{n(2N - n + \frac{1}{2}\chi_{1-\propto})}{N\chi_{1-\propto}}, \quad R_2 = \frac{n(2N - n + \frac{1}{2}\chi_{\propto})}{\chi_{\propto}},$$

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$$q_1 = 0; q_2 = \frac{R_0}{N}, (n = 0); \quad q_1 = \frac{n}{NR_1}; q_2 = \frac{n}{NR_2}, (n \neq 0). (5)$$

The confidence limits of the probability of failure-free operation are estimated according to the following formulas:

$$P_1 = 1 - q_2, \; P_2 = 1 - q_1 . \qquad (6)$$

Results

When examining $N = 200$ products with $n = 20$ failures and $n = 0$ without failures estimates of the confidence limits of the probability of failure-free operation of products P were found at the given confidence probability ∝=0.95.

1) $N = 200, \; n = 20, \; q = \frac{n}{N} = 0.1, \; R_1 = 1.49, R_2 = 0.7$

$$q_1 = \frac{n}{NR_1} = \frac{20}{200 \cdot 1.49} \approx 0.0671, \qquad q_2 = \frac{n}{NR_2} = \frac{20}{200 \cdot 0.7} \approx 0.1429, \quad P = 1 - q = 0.9$$

$$P_1 = 1 - q_2 = 1 - 0.1429 = 0.8571, \; P_2 = 1 - q_1 = 1 - 0.0671 = 0.9329 .$$

2) $N = 200, n = 0, \qquad q = 0, R_0 = 2.29, \qquad q_1 = 0, \; q_2 = \frac{R_0}{N} = \frac{2.29}{200} \approx 0.0115,$

$$P = 1 - q = 1 - 0 = 1, \qquad P_1 = 1 - q_2 = 1 - 0.0115 = 0.9885, \; P_2 = 1 - q_1 = 1 - 0 = 1 .$$

Conclusion

The described approach can be effectively used to analyze product reliability indicators at the stages of aircraft design, production and operation.

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